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LOS ALAMOS SCIENTIFIC LABORATORY

OF THE UNIVERSITY OF CALIFORNIA o LOS ALAMOS NEW MEXICO

CASTLE AND TEAPOT ELF EM SIGNALS

ALBERT LOOP DATA

(Title Unclassified)

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LOS ALAMOS SCIENTIFIC LABORATORY
OF THE UNIVERSITY OF CALIFORNIA LOS ALAMOS NEW MEXICO

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ALBERT LOOP DATA
(Title Unclassified)

Data by:
John Malik
Roger Ray
Neel Glass

Report written by:
John Malik

[redacted]

Contract W-7405-ENG. 36 with the U. S. Atomic Energy Commission

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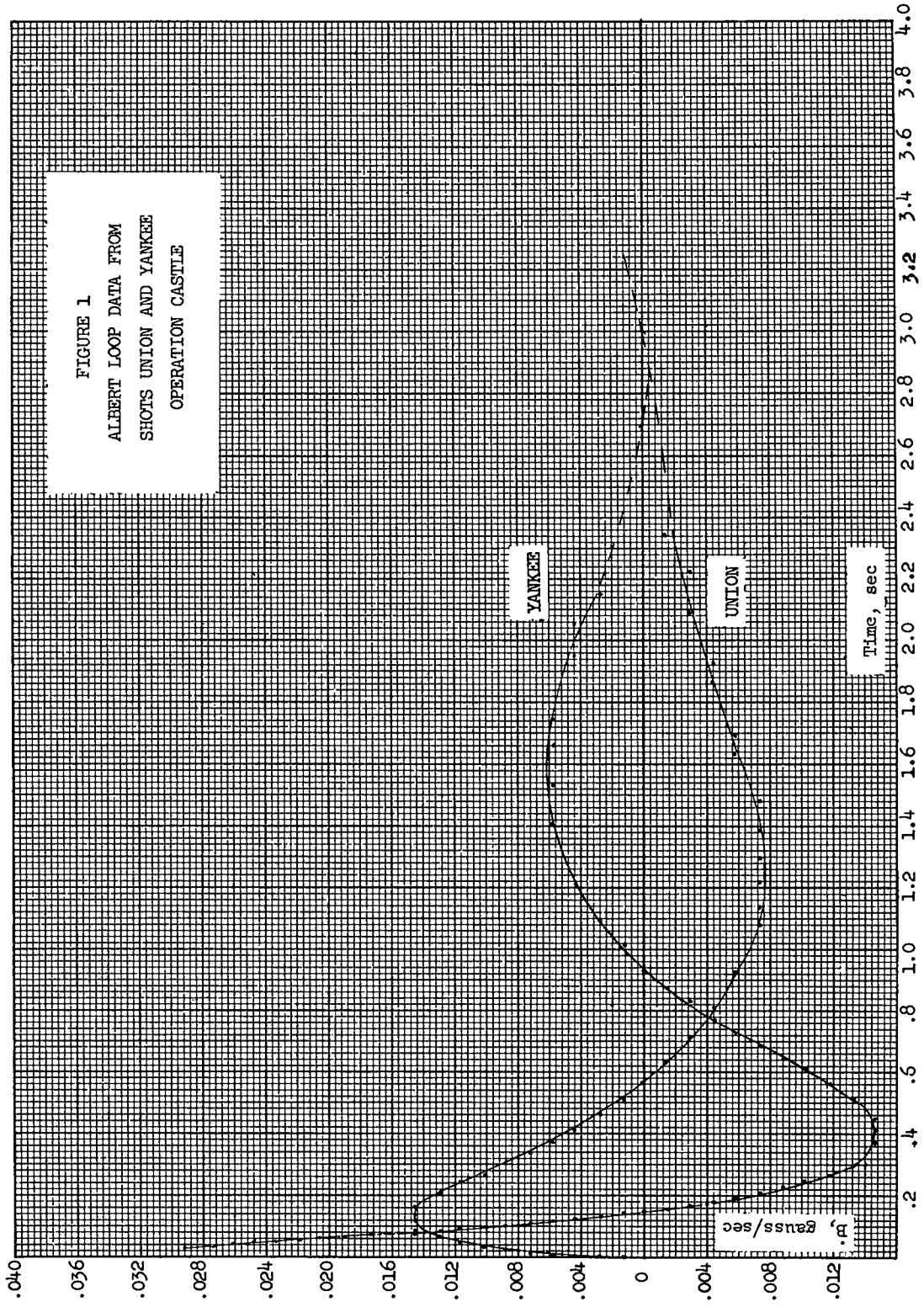
CASTLE ELF EM SIGNALS (data by J. Malik and R. Ray)

During Operation Castle, in conjunction with some diagnostic measurements utilizing electromagnetic radiation from the nuclear burst, we looked at the voltage induced in a large loop using a brush recorder. The loop was about 20 feet square and had 40 turns; the turns-area product was 1375 square meters. The loop was oriented such that its plane was vertical and contained the point of detonation; i.e., we were looking at $\dot{B}_{\phi}$. The brush recorder was a two pen instrument with response from d.c. to somewhat over 100 cps. System checks made using a parallel loop energized by a battery to give a sharp rising field indicated the resolution was set by the recorder and that it did not overload or misbehave in a fashion to produce the signals observed.

The signals recorded from Union, 7 MT, and Yankee, 13.5 MT, at our recording station on Japtan, 335 km west of the burst at Bikini atoll, are shown in Figure 1. The zero time is known to be simultaneous to less than 1/60 sec of that of the fast component by virtue of a timing pulse from the fast EM system fed to the second pen. A similar measurement was attempted on shot Nectar, 1.7 MT, 35 km NNW of the station, but no signal was observed. No post shot check was made, and hence it is not certain the equipment was operative (heavy rains may have caused malfunction).

[redacted]



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The sensitivity had also been reduced by a factor of 30. The above data were first reported in WT-949;[1] the data in Figure 1 are from a recent redo of the record. The original records do not exist, hence the points were taken from a reproduction. (The Union data appear to have been misread for the plot in WT-949.)

Station coordinates were 162° 24' E, 11° 26' N; of the Union burst point 165° 23' 14" E, 11° 39' 59" N; of the Yankee burst 165° 23' 13" E, 11° 39' 56" N; of the Nectar burst 162° 11' 47" E, 11° 40' 14" N. Other data which may be of interest: the earth's magnetic field is about 0.33 gauss with a declination of 13.5°. At the burst location there is a negative anomaly of about 750 gamma; the maxima being some 25 to 30 km to the north and northwest [2] from the burst points.

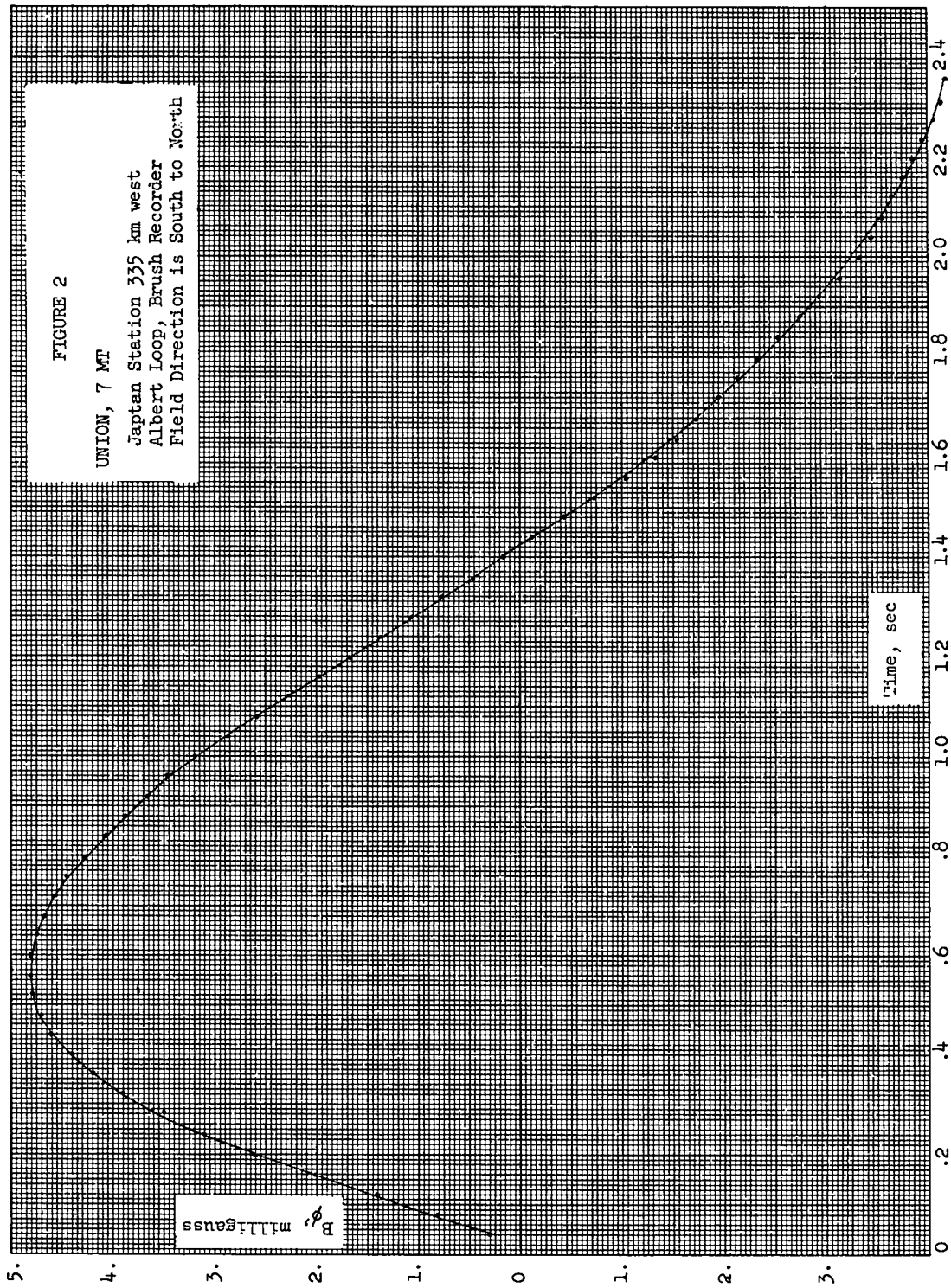
Union was fired in normal weather conditions - fair with scattered clouds. Yankee weather had squalls; lightning strokes were visible on the fireball film from ground to cloud.

In attempting to explain the signals several mechanisms have been postulated but none has seemed to completely explain the signals.

One mechanism proposed is that of the hydrodynamic motion of the ionized air (ions mainly of N_2^+, O_2^- and $(C^{14})^-$). If in three dimensional space a conducting sphere of radius a expanding in a uniform field B_o would produce a field at a distance D, then $B = \frac{B_o}{2} (\frac{a}{D})^3$. Putting in values of a(t) the relation gives fields some 10^6 smaller than those observed.

1. John S. Malik and Roger Ray, Operation Castle, Electromagnetic Experiments, WT-949 (LASL), December 1954.

2. Aldredge, Keller, Dicktel, Magnetic Structure of Bikini Atoll, U. S. Govt. Printing Office (1954), Geol. Survey Report 260-L.



[redacted]

Regarding the region between the earth and the ionosphere as a waveguide and considering the propagation in this region, the field dependence goes as the inverse square ~~foot~~ of the distance [1]. If the treatment is valid for such short distances, this would give fields of the right order of magnitude.

Another postulated mechanism is the ringing of the concentric spherical cavity formed by the conducting earth and conducting region of the atmosphere. The fundamental mode is like 4 cps, and damping and dispersion might be like the observed signals. Energy considerations give fields low by a factor like 10^4. (Square root of ratio of volume of field destroyed to the total volume of cavity.)

The mechanism of the spheric or whistler is attractive in that dispersion gets maximum play. This is the guiding of the signals by a magnetic line of force to the conjugate point in the opposite hemisphere and then reflected back to the origin. However, Bikini is near the magnetic equator, and low frequency whistlers should not be observed. The fact of an anomaly (which could be represented by a radial dipole in the manner of McNish [2] might however produce some effect of the whistler, though not likely of the magnitude seen.

The anomaly might also indicate local dynamo currents in the earth; and a teetering of the atoll surface, due to the burst, might produce a moving conductor in the field of these localized currents to give some signal.

1. J. R. Wait, Mode Theory of VLF Propagation, Proc. IRE 45, 760 (1957)
2. A. G. McNish, Physical Representations of Geomagnetic Field, Trans. Am. Geophy. Union 21, 287 (1940)

[redacted]

Since it is tied to physical mass movement it is hard to imagine such fast motion, particularly that which would be required for the Yankee signal. It would also have the characteristics of a magnetic dipole as in the first mechanism proposed.

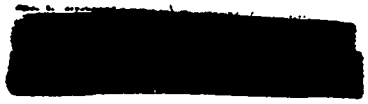
The signals seem to remain unexplained. If a mechanism exists which could also be excited by an underground burst, it would be most interesting for the Geneva proposal. In this light, and also considering the Plumbbob data of Peter Haas of Diamond Ordnance Laboratories, it seems worth extending the frequency coverage of contemplated EM measurements on any future shots down to zero cycles; to place stations both on EW and NS lines and at at least two distances. Further thought should also be given to measurements at both the conjugate point and the antipode.

TEAPOT ELF EM SIGNALS (data by Neel Glass)

Measurements of the low-frequency signal induced in loops located inside bunkers were made by Neel Glass on Teapot shots Apple I and Zucchini[1]. He used two 2000 turn, 10 inch diameter loops, one oriented with the plane of the loop perpendicular to the line from zero to the bunker, the other vertical and parallel to this line. A brush recorder (frequency response 0.5 to 100 cycles) was used to record the signals induced in the loops.

Apple I was a 14 KT burst on a 500 foot tower in Area 4. Recording was inside station 4-300, 3000 feet due east of the tower. The loops were located inside a screened recording room erected in the coax room of that bunker. The prime experiment involved measurement of the signals from detectors located at ground zero; 7/8 inch coax was used to transmit the

1. A similar measurement was also attempted on Apple II but no signals were observed.



signals. (There were also a number of 3 1/8 inch coax coming into the coax room from points intermediate between tower and station.) The outer conductors of the 7/8 inch coax were bonded to the inside wall of the screened room. From this point smaller coax were used to transmit and delay the detector signals to the prime measurement oscilloscopes. (The delay cables were mainly coiled above the oscilloscope racks near the ceiling. The EM loops were located near the ceiling at the end of the room farthest from zero and the coax entry.)

Zucchini was a 28 KT burst on a 500 foot tower in Area 7. Recording was done in the coax room addition of station 7-300, 3000 feet south of the tower. This room was not shielded. The EM loops here were located near the wall through which the coax (7/8 and 3 1/8 inch) entered the bunker and within 1 or 2 feet of the cable. The outer conductors of the coax were strapped together.

The power system for all the recording equipment used a motor-generator set with flywheel; timing signals were used to control power and cameras. The brush recorder motors were started at -1 sec and all power turned off at about +1 sec; the MG set with flywheel would, however, maintain some voltage for times longer than +1 sec. The power turn off at +1 sec of the prime oscilloscope introduced signals into the loops on dry runs as well as following the shots.

Figures 3 and 4 show the records obtained on the two shots and Figures 5, 6 and 7 the data abstracted from the records after some smoothing. Figures 8 and 9 are the integrals of the previous figures giving the field versus time. The signals at later times, i.e., at about 1 sec, are the

FIGURE 3

APPLE I, 14 KT

Station 4-300, 3000' east
+ is a South to North field
Brush Recorder, 10" dia 2000 turn loop

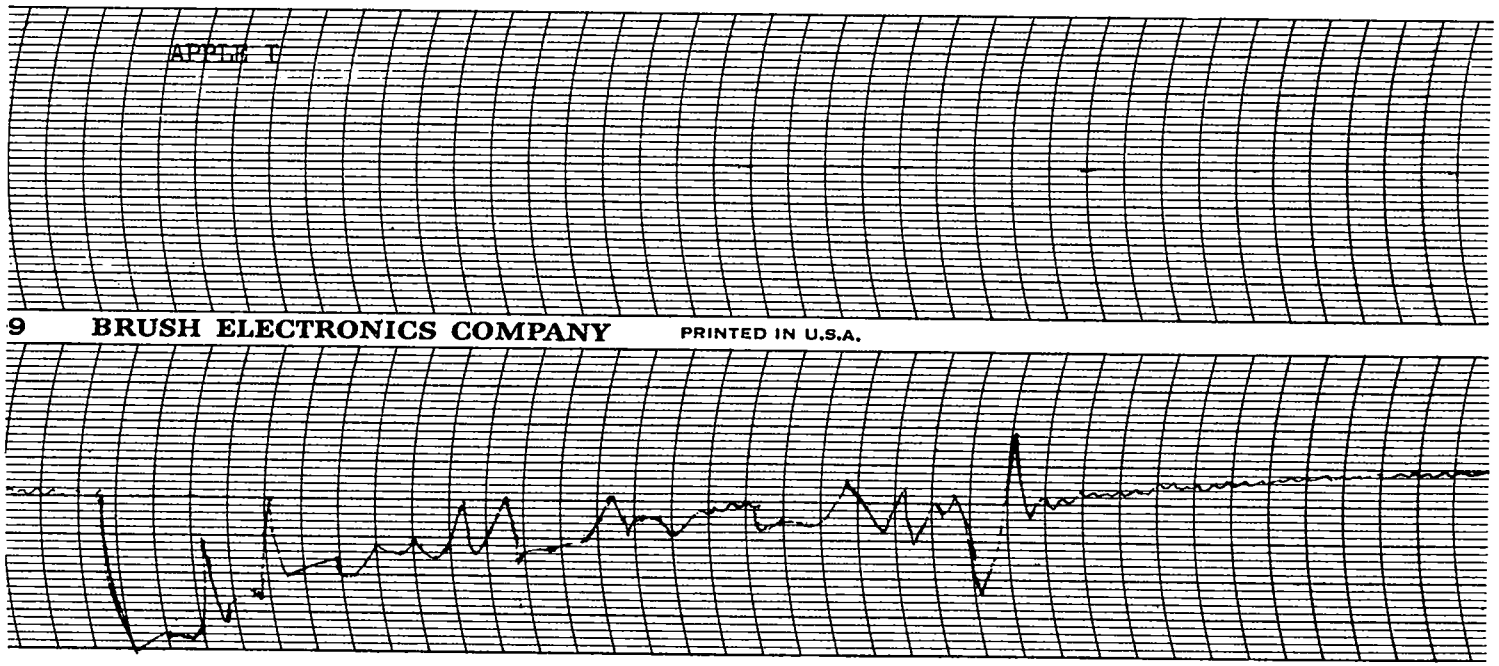


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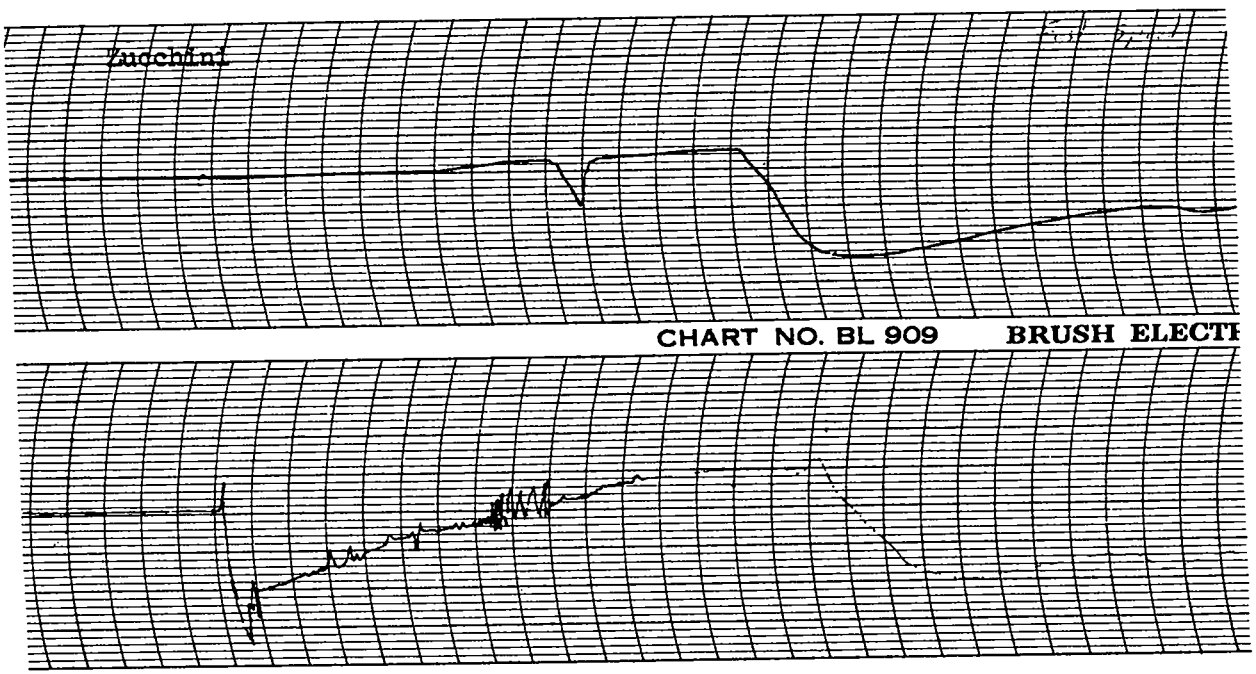
FIGURE 4

ZUCCHINI, 28 KT

Station 7-300, 3000' from ground zero
+ is an East to West field
Brush Recorder, 10" dia 2000 turn loop



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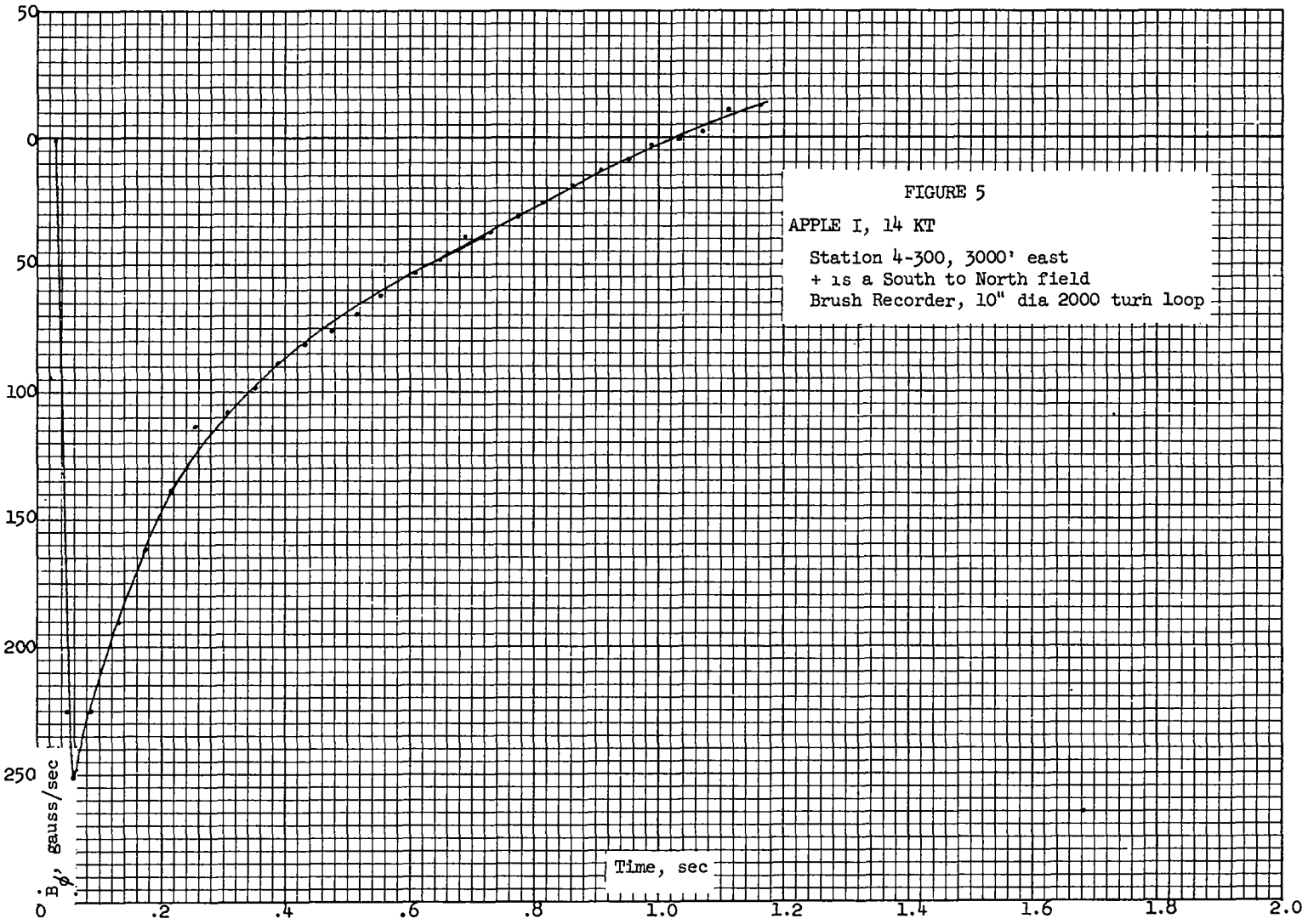

FIGURE 5

APPLE I, 14 KT

Station 4-300, 3000' east
+ is a South to North field
Brush Recorder, 10" dia 2000 turn loop

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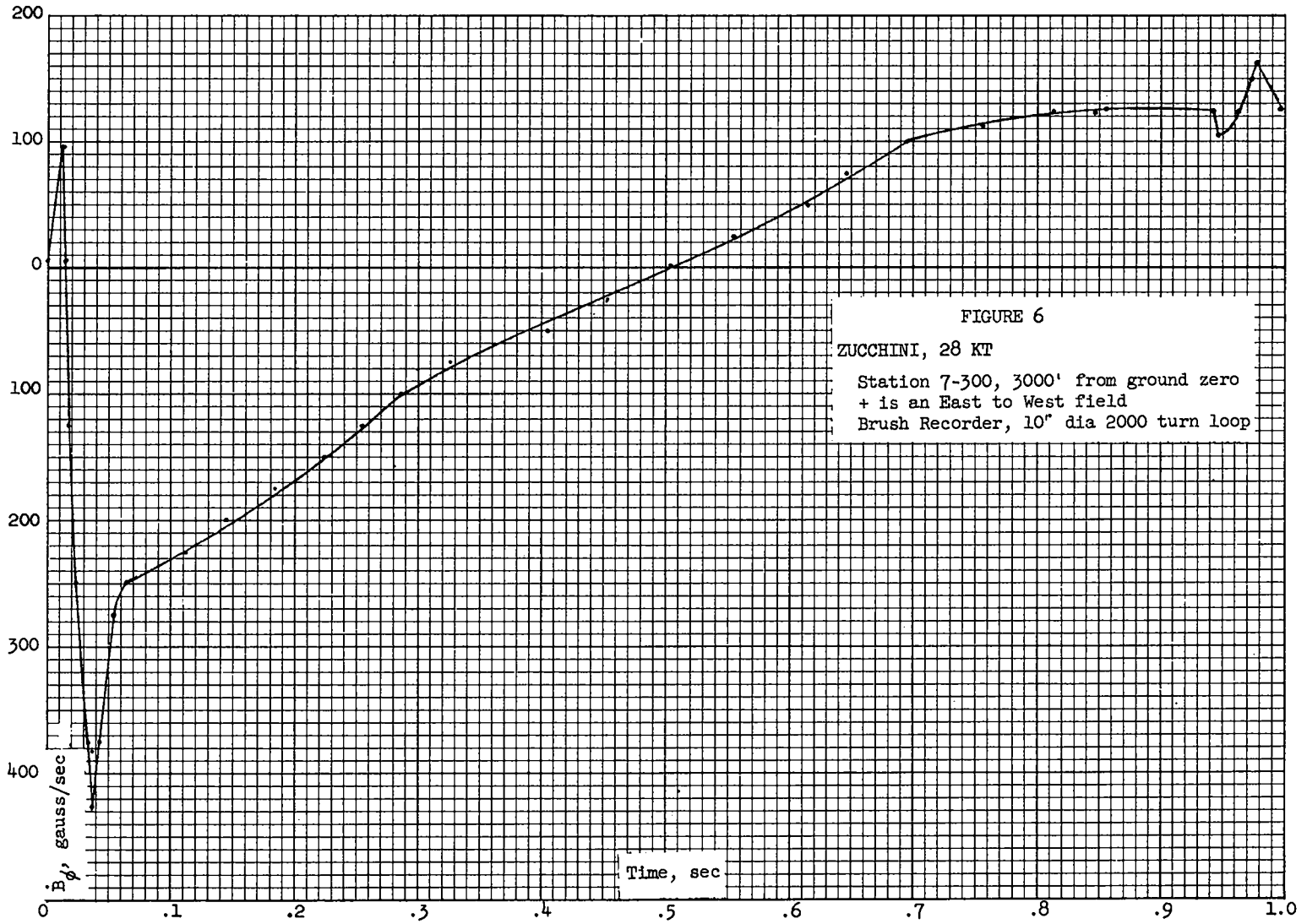

FIGURE 6

ZUCCHINI, 28 KT

Station 7-300, 3000' from ground zero
+ is an East to West field
Brush Recorder, 10" dia 2000 turn loop

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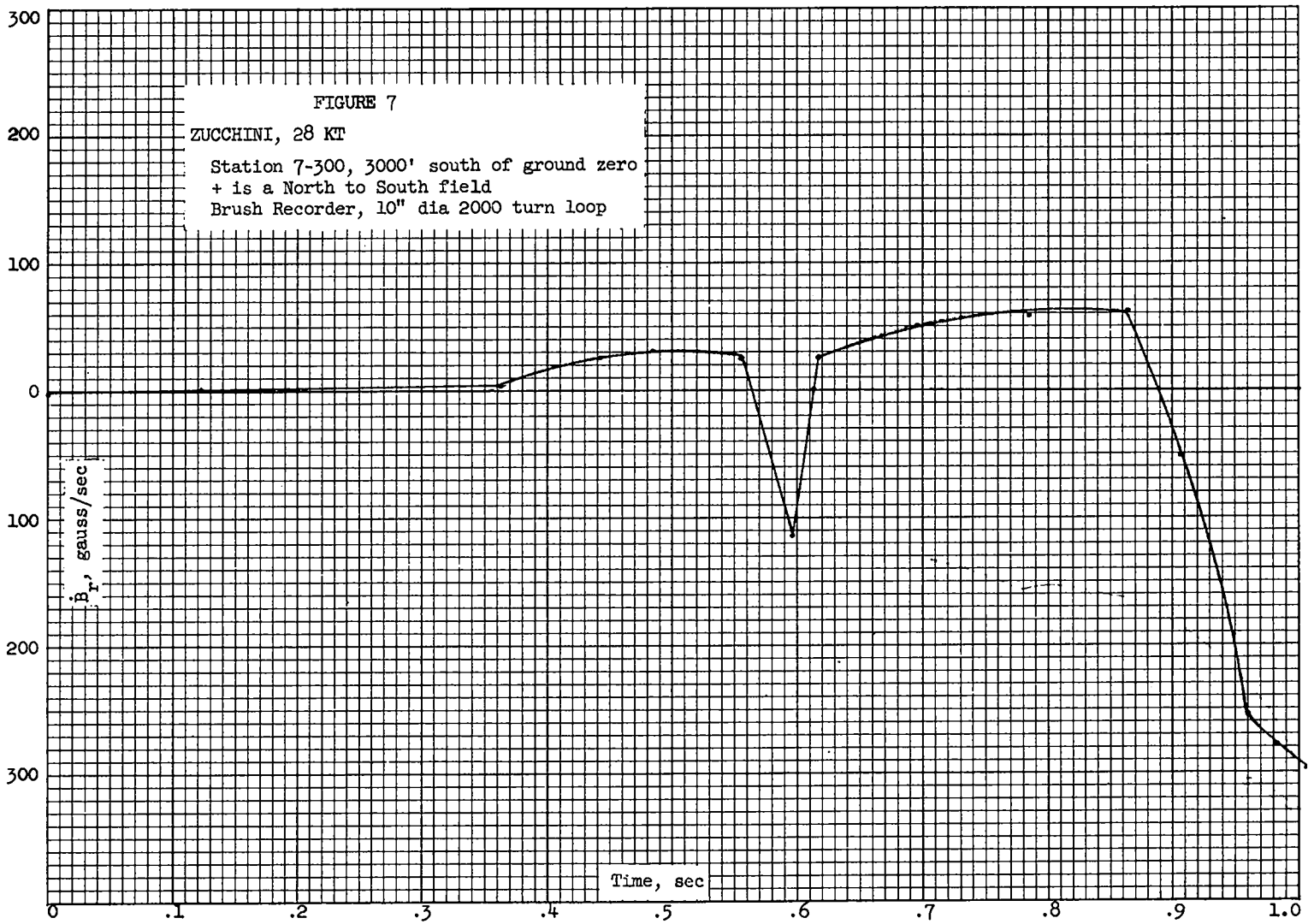
FIGURE 7

ZUCCHINI, 28 KT

Station 7-300, 3000' south of ground zero
+ is a North to South field
Brush Recorder, 10" dia 2000 turn loop



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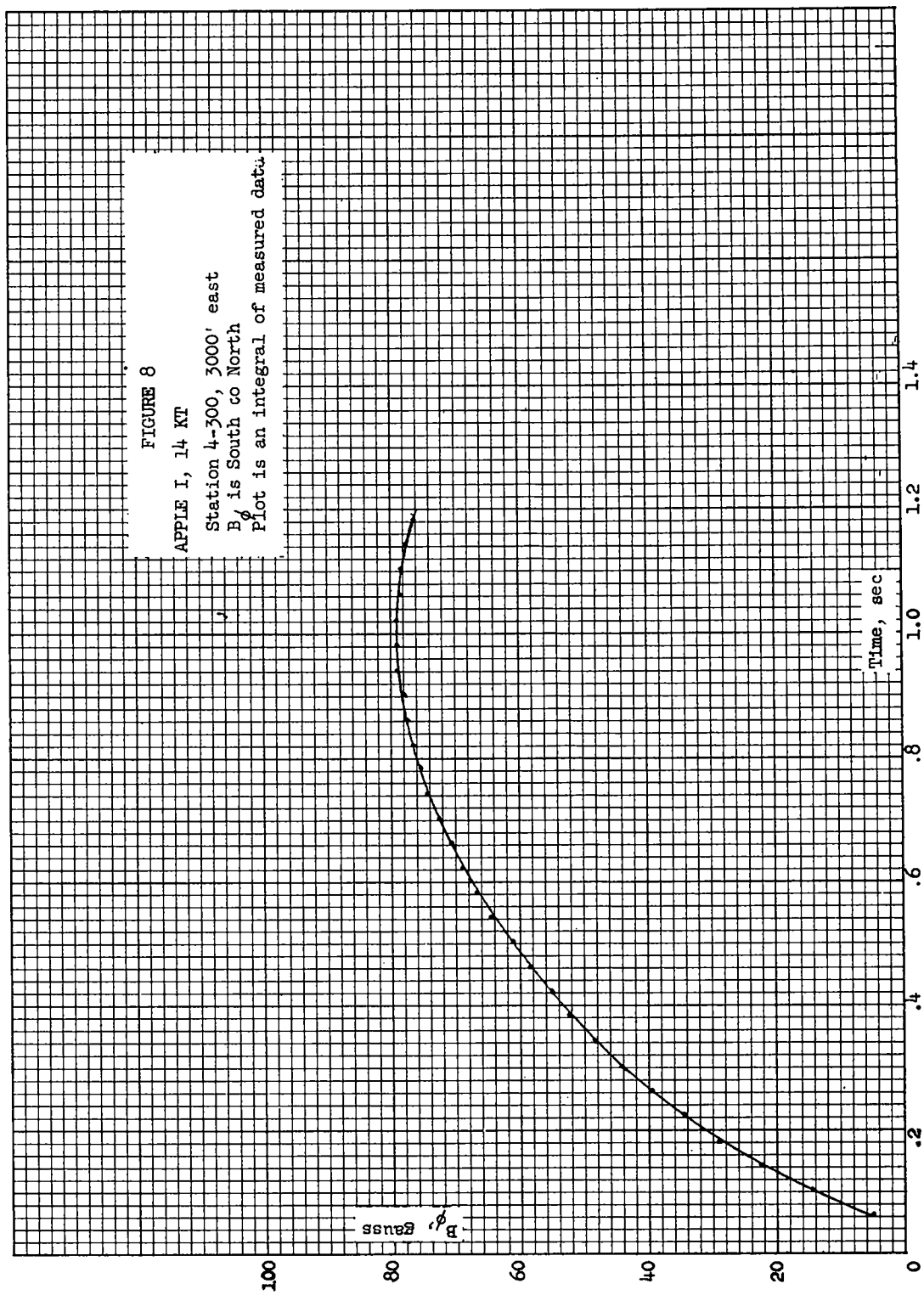

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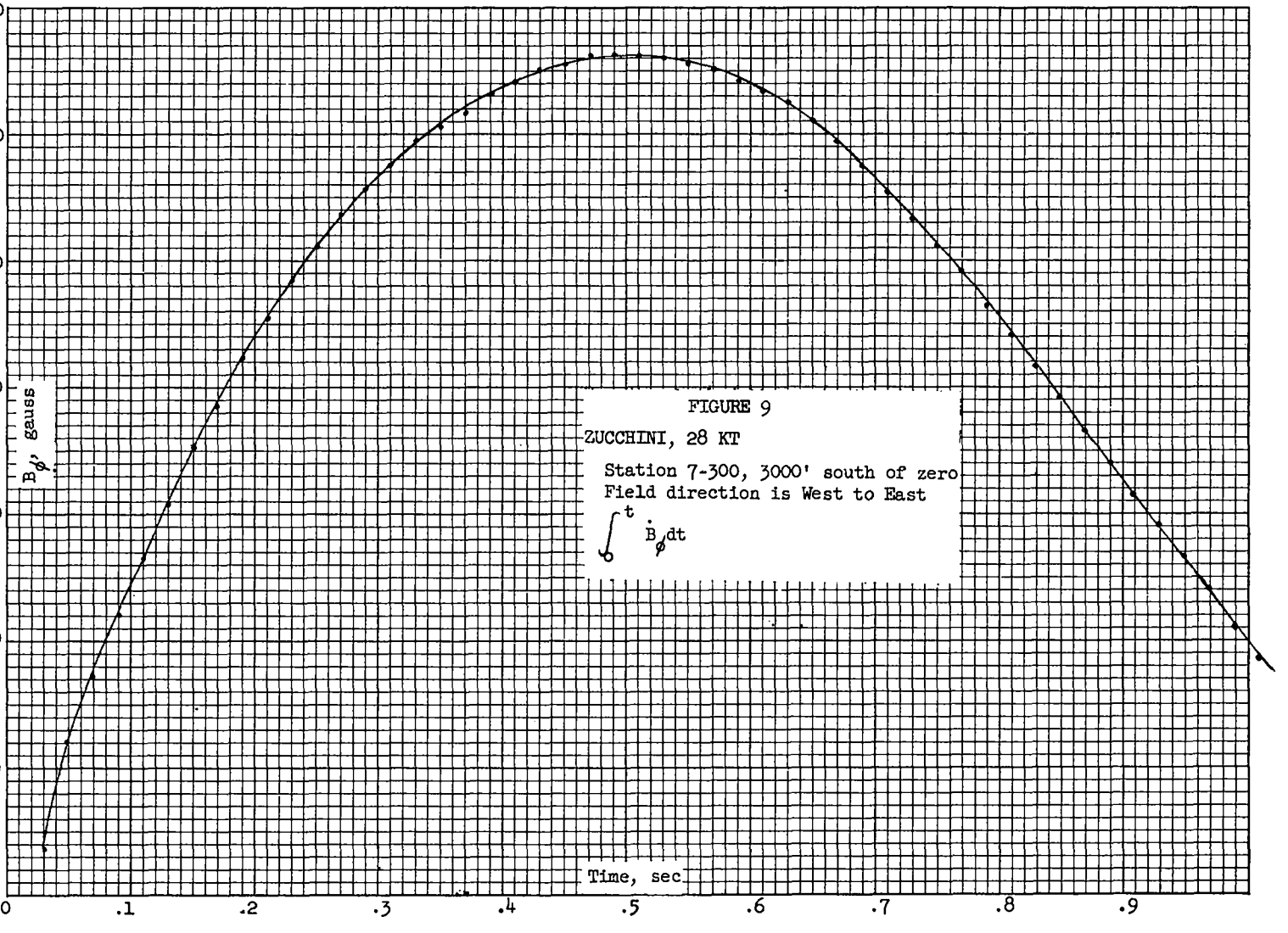

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same as those observed following dry runs and were disregarded.

The origin of the signals is unknown, but it is conjectured they were produced by currents brought into the bunkers on the various coax leading into the bunker. Harding, WT-813[1], recorded currents of about 500 amp on No. 10 bare copper wire which was connected to counterpoise or station ground at 3000 feet. He did not record waveshape. If the currents were limited by resistance of the conductor the current in the outer conductor of a 7/8 inch aluminum coax might be about 30 times this or 1.5×10^4 amp and on 3 1/8 coax, 10^5 amp. These currents probably would be limited by the station grounds however. For the case of Apple I and considering 10 coax, the field at 5 meters from currents of the magnitude is like 60 gauss - the right order of magnitude. For Zucchini where the coax were 3 1/8 and loops were closer, fields like 2000 gauss are indicated. Clearly fields of greater magnitude than observed are possible due to currents on conductors entering the structure. It is conjectured that this is the explanation of the observed fields.

ION CHAMBER EXPERIMENT (data by Neel Glass)

This experiment was an attempt to measure gamma radiation inside the bunker (Station 1210) used by J-16 for Union. The bunker was located 2100 meters nearly due north of zero of Union, a surface burst. The ion chamber was about a meter on a side and was connected to the log amplifier of the "hole in the ground" recorder in use by Ragan and Theobald. The equipment was located in the northeast corner of the recording room of the bunker inside the screened room. The recording equipment is self

1. John M. Harding and George E. Baker, Operation Upshot-Knothole, Measurements of Electric Transients in the Earth, WT-813, December 1953.

contained, battery powered using a 3 KP 11 CRT mounted vertically and shielded by iron pipe, the motion of the spot being recorded by a strip film camera. A negative deflection was obtained which eventually crossed zero and remained positive for the duration of recording. The negative deflection was attributed to a magnetic field deflecting the spot of the CRT; the subsequent positive deflection might have been due to a signal from the ion chamber. To estimate the magnitude of the magnetic field required to deflect the spot, the unit was rotated to obtain the deflection caused by the earth's field. The deflection corresponding to the earth's field was 0.044 mm; the peak signal deflection was 0.73 mm. Taking the horizontal component of the earth's field as 0.33 gauss the signal peak corresponds to a field of 5.5 gauss. The direction of the spot motion was such as to be due to a "southerly" or nearly radial field, i.e., opposite to the earth's field. It should be noted, however, that an azimuthal field would have caused a deflection in the same direction as the time axis and would hence alter the time scale as measured. Also the orientation of the equipment was not precisely known, and hence the southerly deflection might have been due to a component of an azimuthal field. A field change of 7 gauss would correspond to about 1 millisecond in film motion. Judging from the record and estimates of errors in orientation, limits of azimuthal field which might have produced the signal are in the range 50-500 gauss, the lower values appearing to be more reasonable when compared to the data taken by Malik and Ray at 320 km.

Figure 10 shows a graphic representation of the data from this experiment.

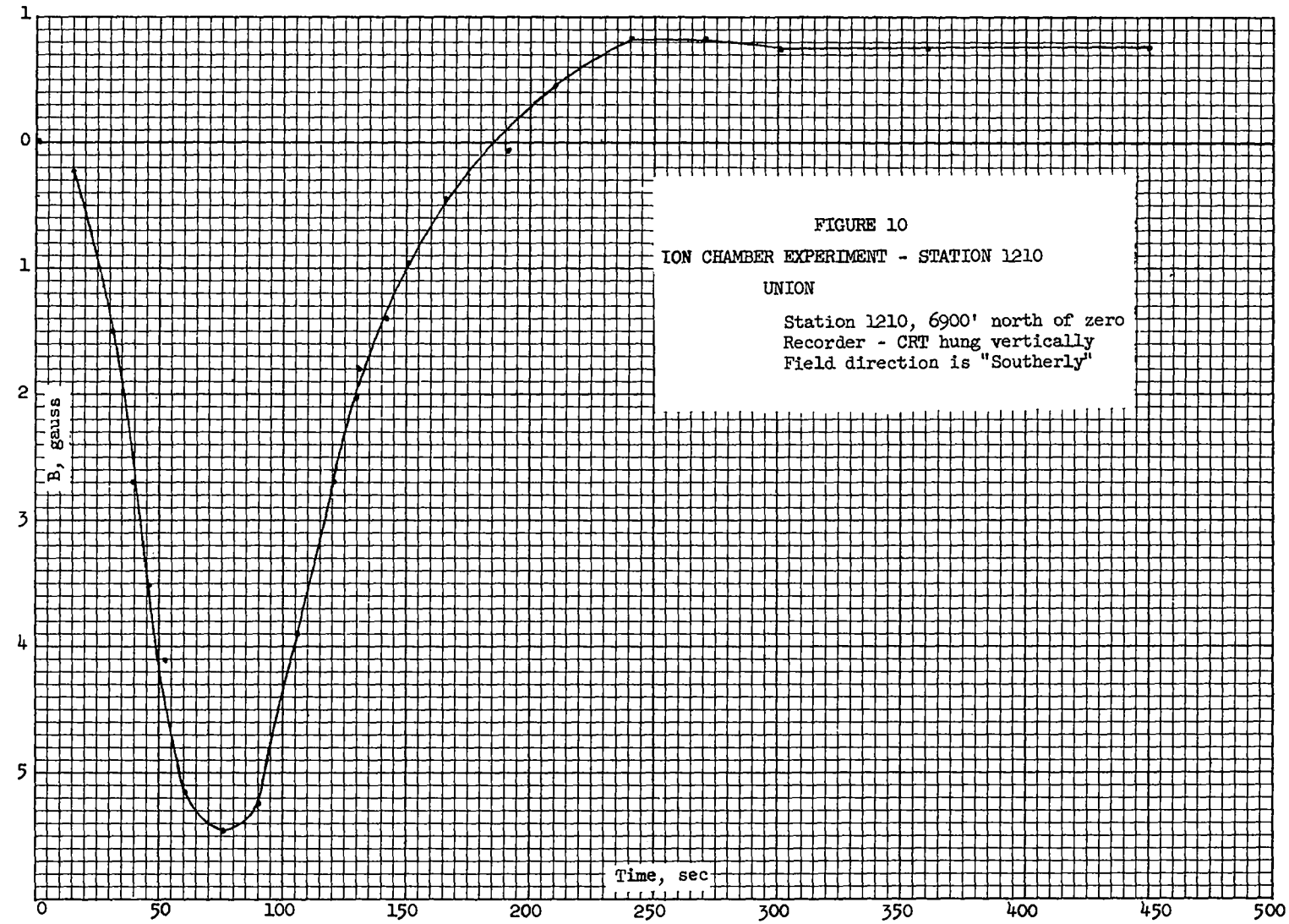

FIGURE 10

ION CHAMBER EXPERIMENT - STATION 1210

UNION

Station 1210, 6900' north of zero
Recorder - CRT hung vertically
Field direction is "Southerly"

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